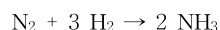


1. Define the following terms briefly.

- ① half-life (반감기) (1 pt)
- ② homogeneous catalyst (균질촉매) (1 pt)
- ③ Le Chatelier's principle (르 샤틀리에의 법칙) (1 pt)
- ④ dominant equilibrium (지배적 평형) (1 pt)
- ⑤ conjugate acid-base pair (짝산-염기쌍) (1 pt)
- ⑥ weak base (약염기) (1 pt)

2. A chemist is studying Haber synthesis:

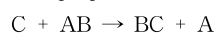


Starting with a closed reactor containing 1.25 mol/L of N_2 and 0.50 mol/L of H_2 , the chemist finds that the H_2 concentration has fallen to 0.25 mol/L after 30 seconds.

① What is the average rate of reaction over time? (3 pt)

② What is the average rate of NH_3 production? (3 pt)

3. For the net reaction $2 \text{AB} + 2 \text{C} \rightarrow \text{A}_2 + 2 \text{BC}$, the following slow first step has been proposed:



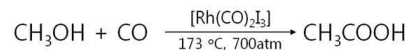
① What rate law is predicted by this step? (2 pt)

② What units are associated with the rate constant for this rate law? (2 pt)

③ Write additional steps that complete the mechanism. (2 pt)

4. If a reaction has an activation energy of zero, how will its rate constant change with temperature? Explain in molecular terms what $E_a = 0$ means. (5 pt)

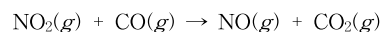
5. The industrial process for forming acetic acid involves a catalyst:



① Draw molecular pictures showing the bond breakage and formation that must occur in the course of this reaction. (4 pt)

② Suggest how the catalyst might make it easier for these reactions to occur. (1 pt)

6. The reaction of NO_2 of CO is a reaction that may occur in automobile exhaust:



Because of its color, it is possible to monitor the concentration of NO_2 with time. A chemist carried out isolation experiment to do kinetics studies on the reaction and obtained the following data.

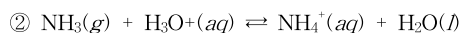
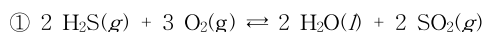
Experiment A: $[\text{NO}_2]_0 = 3.5 \times 10^{-3} \text{M}$, $[\text{CO}]_0 = 0.40 \text{M}$					
Time(s)	0	240	480	720	960
$[\text{NO}_2] (10^{-3} \text{M})$	3.5	2.5	1.9	1.6	1.3

Experiment B $[\text{NO}_2]_0 = 3.5 \times 10^{-3} \text{M}$, $[\text{CO}]_0 = 0.6 \text{M}$					
Time(s)	0	240	480	720	960
$[\text{NO}_2] (10^{-3} \text{M})$	3.5	2.5	1.9	1.6	1.3

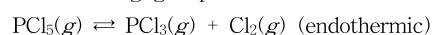
① Draw graphs to determine the rate law for this reaction. (5 pt)

② Evaluate the rate constant. (2 pt)

7. Write the equilibrium constant expression for each of the following reactions. (each 2 pt)

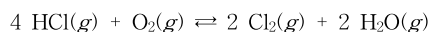


8. Consider the following gas-phase reaction:



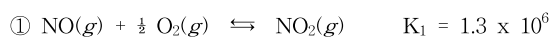
Describe four changes that would drive the equilibrium to the left. (5 pt)

9. At high temperature, HCl and O₂ react to give Cl₂ gas:

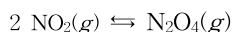


If HCl at 2.30 bar and O₂ at 1.00 bar react at 750 K, the equilibrium pressure of Cl₂ is measured to be 0.93 bar. Find the value of K_{eq} at 750 K. (7 pt)

10. Using reactions and equilibriums of ① and ②, determine the value of K₃. (5점)



11. Using thermodynamic data given below, calculate K_{eq} for the following reaction at 298 K와 825 K. (7 pt)



	NO ₂ (g)	N ₂ O ₄ (g)
ΔG _f ^o (kJ/mole)	51.3	99.8
ΔH _f ^o (kJ/mole)	33.2	11.1
S ^o (J/mol K)	240.1	304.4

12. Calculate the concentrations of hydronium and hydroxide ions in a solution prepared by dissolving 0.448 g of HCl gas in enough water to make 325 mL. HCl molar mass=36.461 g/mol. (7 pt)

13. For a 0.35M aqueous solution of trimethylamine, N(CH₃)₃, do the following:

① Identify major and minor species. (2 pt)

② Compute concentrations of all species. (4 pt)

③ Find the pH. (2 pt)

14. Hydrazine(N₂H₄) has K_b=1.3 × 10⁻⁶.

① Use Lewis structures to illustrate the equilibrium reaction of K_b. (2 pt)

② Calculate the pH of a 2.00 × 10⁻¹M solution of N₂H₄. (4 pt)

15. Acetic acid(CH₃CO₂H) is weaker than chloroacetic acid(ClCH₂CO₂H).

① Draw Lewis structures of these two acids. Draw an arrow indicating the effect of the Cl atom on the electron density in the rest of the molecule. (3 pt)

② Use these drawing to explain why chloroacetic acid is the stronger acid. (3 pt)

16. Determine the concentrations of the ionic species present in a 0.35 M solution of sodium sulfite (Na₂SO₃), sulfuric acid (H₂SO₄) K_{a1} = 1.4 × 10⁻², K_{a2} = 6.3 × 10⁻⁸ (8 pt)

***** 문제 해결에 필요한 상수들 *****

● 0 K = -273.15 °C, K_w = 1.00 × 10⁻¹⁴

● 기체 상수 R = 8.314 J mol⁻¹ K⁻¹

● ΔG_o = ΔH^o - TΔS^o ; ΔG^o = -RTlnK_{eq}